DURABILITY PERFORMANCE OF LIGHTWEIGHT CONCRETE CONTAINING OIL PALM ASH SUBJECTED TO AIR CURING

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

Cement manufacturing industry and solid waste disposal from palm oil industry in Malaysia had caused a bad impact towards the environment. The production of cement produces high amount of carbon dioxide emission while the disposal of palm oil waste such as oil palm ash (OPA) and palm oil boiler stone (POBS) are rather be disposed in landfills without profit return. This has made the palm oil waste as a source of material to partially replace the cement content in the concrete mix as to reduce the environmental pollution and amount of waste being disposed. Moreover, the use of POBS as course aggregate replacement in concrete can perpetuate the natural resources such as granite. Hence, a research to study the durability performance of lightweight concrete (LWC) containing oil palm ash as partial cement replacement that is subjected to air curing is made for 23 weeks. In fact, LWC containing OPA exhibits low water absorption as it is high in pozzolanic reaction. This study also emphasized the durability performance in terms of both acid and sulphate resistance towards LWC. Trial mix is made in the early stage of concrete mix design to select the best performing OPA lightweight concrete while taking account into durability and strength. As such, concrete Grade 60 with 20% of OPA as partial cement replacement is the best mix to sustain acid and sulphate attacks with a great durability and strength. All in all, this study proves that LWC containing OPA is potentially be applied in construction industry for structural application as it can minimize the cost of production while at the same time reduces the dead load of concrete structure.

ABSTRAK

Industri pembuatan simen dan pelupusan sisa pepejal daripada industri minyak sawit di Malaysia telah menyebabkan kesan yang tidak baik terhadap alam sekitar. Pengeluaran simen menghasilkan jumlah pelepasan karbon dioksida yang tinggi manakala pelupusan sisa minyak sawit seperti abu kelapa sawit dan batu dandang minyak sawit dilupuskan di tapak pelupusan tanpa pulangan keuntungan. Ini telah menjadikan sisa kelapa sawit sebagai sumber bahan bagi menggantikan kandungan simen dalam campuran konkrit untuk mengurangkan pencemaran alam sekitar dan jumlah sisa yang dilupuskan. Selain itu, penggunaan batu dandang minyak sawit penggantian padang agregat dalam konkrit boleh mengekalkan sumber-sumber semula jadi seperti granit. Oleh itu, penyelidikan untuk mengkaji prestasi ketahanan konkrit ringan yang mengandungi abu kelapa sawit sebagai separa penggantian simen yang tertakluk kepada pengawetan udara dibuat untuk 23 minggu. Malah, konkrit ringan mengandungi kandungan abu kelapa sawit dengan penyerapan air yang rendah kerana ia adalah tinggi dalam reaksi pozolanik. Kajian ini juga menekankan prestasi ketahanan dari segi kedua-dua asid dan rintangan sulfat terhadap konkrit ringan. Cubaan campuran dibuat dalam peringkat awal reka bentuk campuran konkrit untuk memilih yang terbaik bagi konkrit ringan yang mengandungi abu kelapa sawit semasa mengambil kira ketahanan dan kekuatan. Oleh itu, gred konkrit 60 dengan 20% abu kelapa sawit sebagai separa pengganti simen adalah gabungan terbaik untuk mengekalkan asid dan sulfat serangan dengan ketahanan yang hebat dan kekuatan yang tinggi. Kajian ini membuktikan bahawa konkrit ringan mengandungi abu kelapa sawit berpotensi digunakan dalam industri pembinaan untuk applikasi struktur kerana ia boleh mengurangkan kos pengeluaran dan pada masa yang sama dapat mengurangkan beban struktur konkrit.

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LIST OF SYMBOLS

kg/m^3	kilogram per cubic metre
mm	millimetre
MPa	megapascal
%	percent
°C	degree Celsius
fc	compressive strength
N/mm^2	newton per square millimetre
m_1	mass of specimens before immersion
m_2	mass of specimens after immersion
µm	micrometre

LIST OF ABBREVIATIONS

LWC	Lightweight Concrete
LWAC	Lightweight Aggregate Concrete
LWA	Lightweight Aggregate
OPA	Oil Palm Ash
POBS	Palm Oil Boiler Stone
ASTM	American Society for Testing and Materials
C-S-H	Calcium silicate hydrate
BS-EN	British Standard
OPC	ordinary Portland cement
HCI	hydrochloric acid
$CaCO_3$	calcium carbonate
CaO	calcium oxide
OPS	Oil palm shell
SO_3	sulphur trioxide
SiO_2	silicon dioxide
$NaSO_4$	sodium sulphate
C_3A	tricalcium aluminate
CO_2	carbon dioxide

CHAPTER 1

INTRODUCTION

1.1 Background Study

Lightweight concrete (LWC) is widely used in the construction industry since it is lighter than the conventional concrete used for construction with a density lower than 2000kg/m^3. As such, the LCW can be found in the making of the component of buildings where it does not impose a great load such as the parapet wall and road liners. It is mostly used due to its porosity that provides a good water absorption for the internal curing to test on the strength and durability of it as to compared with the conventional concrete. There are basically three types of lightweight concrete that include Lightweight Aggregate Concrete, Aerated Concrete and No-Fines Concrete.

The reasons why the lightweight concrete is widely used are because it can reduce the dead load of the concrete structure while at the same time can produce a low cost of production in terms of the size reduction, less steel reinforcement work and low volume of concrete. LWC is also high in fire resistivity that can provide more efficient strength-to-weight ratio while improve the thermal property. In addition, LWC is designed to achieve the similar properties as the normal concrete such as the durability except for which LWC is made of both the lightweight course and fine aggregates. Knowing that the lightweight aggregates used are usually consist of expanded shale, slate or clay materials that had been fired in a rotary kiln in order to develop a porous structure.

Palm Oil Boiler Stone (POBS) is the waste product of the palm oil industry that is produced in the boiler when the husk fibre and shell of palm oil is burned to generate energy for the refineries (Mohd, 2012). In Malaysia, the palm oil is widely produced year by year since it gets high demand in the market. Palm oil boiler stone (POBS) is a waste

by-product from the incineration process of oil palm shells and fibres. They are porous and lightweight in nature, which makes them suitable for use as a lightweight aggregate (LWA) (Kanadasan & Abdul Razak, Materials & Design (1980-2015), 2014).The number of palm oil waste increases as the number of palm oil production increases which then will affect the environment if the waste is not being disposed wisely. Furthermore, using the POC as the partial cement replacement can cause a higher water absorption for the LWC and the shrinkage with low modulus of elasticity. The characterization of such waste to identify its suitability as a cement replacement material, can ultimately lead to lower carbon footprint concrete (Karim & Hashim, 2017).The palm oil boiler stone is usually irregular in shape with a greyish colour and high in porosity. The utilization of waste by-products in concrete has garnered positive outcomes over the past few decades in terms of the cost savings and conservation of natural resources (Kanadasan & Sarker , 2015).

1.2 Problem Statement

As for this study, the palm oil waste is use in the lightweight concrete because palm oil is produced numerously in Malaysia and plus, the supply of the natural aggregate in the making of lightweight concrete that is cement is about to decrease since the demand is getting higher. The production of the cement is decreasing due to high demand and fast development in construction industry while knowing that the process of making a cement will takes time since it needs to burn and process in such a long time.

However, to eliminate the use of palm oil is very impossible since it is one of the main contributor to our country in terms of economy since Malaysia is the second biggest palm oil exporter in the world after Indonesia. But not to worry because the construction industry can use the palm oil waste as the ingredient or mix to make a concrete in order to minimize the disposing of the waste because the waste can lead to a harmful environment such as the air pollution and soil pollution since the palm oil waste is being dumped in the landfills. Other than that, people might also get exposed to the disease if keep consuming the water that flows through the waste disposal area and the landfills in Malaysia is increasing from time to time if the palm oil waste is not being disposed wisely. Making the POC as the partial cement replacement in the making of lightweight concrete is a little as much helping our country to minimize these problems in a long

period of time because POC has a similar physical property as the conventional aggregate hence, the price of the LWC that had been mixed with the POC is cheaper than the conventional price. The concerns over paucity and supplies of raw materials have led researchers to identify alternative materials that could be incorporated as partial cement replacement in concrete production,

1.3 Objective of Research

The objectives of the study are:

i. To determine the compressive strength of the lightweight concrete containing Oil Palm Ash (OPA)
ii. To determine the acid resistance of the lightweight concrete containing Oil Palm Ash (OPA)
iii. To determine the water absorption and sulphate attack on the lightweight concrete containing Oil Palm Ash (OPA)

1.4 Scope of Research

This study is focused on the durability of the lightweight concrete containing palm oil fuel ash as partial cement replacement. The lightweight concrete is subjected to air curing for 28 days. This study is to test the compressive strength of the LWC whether it is stronger or not as to compare with the conventional LWC in the construction industry. There are 60 concrete cubes in total for this study.

In this study, the immersing solution that had been used to test the durability of the LWC is hydrochloric acid (HCI) and sodium sulphate (NaSO4) solution. In fact, hydrochloric acid is a strong acid that can be a corrosive acid towards concrete.

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